

Subject List for
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Subjects

Engineering Mathematics - I

Basic Mechanical Engineering

Engineering Mathematics - II

Industrial Chemistry

Basic Electrical Engineering

Que	Que Marks	Obt. Marks
Q.1 A)	3	3
Q.1 B)	3	N
Q.2 A)	6	4
Q.2 B)	6	N
Q.3 A)	6	N
Q.3 B)	6	4

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Question No. 1

Q1 A) For units of :-

i) Active Power (P)
Formula :-
$$P = V \times I \times \cos \phi$$

Unit = W or kW (Watts) or (kilowatt)

ii) Reactive Power (Q)
Formula :-
$$Q = V \times I \times \sin \phi$$

Unit = VAR or KVAR

iii) Apparent Power (S)
Formula
$$S = V \times I$$

Unit = VA or kVA

Power triangle :-

VA (Apparent Power) S
VAR (Reactive Power) Q
P (Active Power) W

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Question No. 2

Q2 A) Given, in the RLC Circuit

Resistance (R) = 50 Ω
Inductance (L) = 0.1 H
Capacitance (C) = 50 μF = 50 × 10⁻⁶ F
Voltage (V) = 230 V
Frequency (F) = 50 Hz

i) Inductive Reactance (X_L)
Formula :- $X_L = 2\pi fL$
$$\therefore X_L = 2\pi \times 50 \times 0.1$$

$$\therefore X_L = 31.42 \Omega$$

ii) Capacitive reactance (X_C)
Formula :- $X_C = \frac{1}{2\pi fC}$
$$\therefore X_C = \frac{1}{2\pi \times 50 \times 50 \times 10^{-6}} = 63.66 \Omega$$

Find Impedance (Z)
$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$Z = \sqrt{50^2 + (31.42 - 63.66)^2}$$

$$Z = \sqrt{2500 + 1039.4176}$$

$$\therefore Z = 59.49$$

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i) current drawn by circuit (I)

$$I_p = \frac{V_m}{Z_m}$$
$$= \frac{330}{59.49}$$
$$I_p = 3.866 \text{ A}$$
$$I_r = \sqrt{3} \times I_p$$
$$I_r = 1.73 \times 3.866$$
$$I_r = 6.68 \text{ A}$$

iv) Power Factor (P.F.)
Formula :- $P.F. = \frac{\text{Resistance (R)}}{\text{Impedance (Z)}} = \cos \phi$ - (1)
$$\therefore P.F. = \frac{50}{59.49} = 0.84$$

$$\therefore \text{Power Factor} = 0.84 \text{ (lagging)}$$

v) Active Power (P)
$$P = V \times I \times \cos \phi$$

From (1) $\cos \phi = P.F.$
$$P = V \times I_r \times P.F.$$

$$P = 230 \times 6.68 \times 0.84 = 1276.912 \text{ W}$$

we know
$$\cos \phi = 0.84$$
$$\phi = \cos^{-1}(0.84)$$
$$\phi = 32.859^\circ$$

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vi) Reactive Power (Q)
$$Q = V \times I \times \sin \phi$$

$$= 230 \times 6.68 \times \sin(32.859^\circ)$$
$$Q = 482.44 \text{ VAR}$$

Question No. 3

Q3 B) Given,

R = 50 Ω
C = 100 μF = 100 × 10⁻⁶ F
V = 100
F = 50 Hz

a) Find Capacitive Reactance (X_C)
$$X_C = \frac{1}{2\pi fC}$$
$$= \frac{1}{2\pi \times 50 \times 100 \times 10^{-6}}$$
$$X_C = 31.83 \Omega$$

a) Impedance :- (Z) :-
$$Z = \sqrt{R^2 + X_C^2}$$
$$= \sqrt{50^2 + (31.83)^2}$$
$$= \sqrt{2500 + 1013.1489}$$
$$Z = 59.27$$

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b) Current (I)

$$I = \frac{V}{Z}$$
$$= \frac{100}{59.27}$$
$$I = 1.687 \text{ A}$$

c) Power Factor (P.F.)
$$P.F. = \cos \phi = \frac{R}{Z}$$

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c) Voltage across Resistor (V_r)
$$V_r = I \times R$$
$$V_r = 1.687 \times 50 = 84.35 \text{ V}$$

f) Voltage across Capacitor (V_c)
$$V_c = I \times X_C$$
$$V_c = 1.687 \times 31.83$$
$$V_c = 53.69 \text{ V}$$

$p.f = \frac{50}{59.27}$
 $p.f = 0.843$ (leading)
 p.f is leading because capacitive is present.

d) phase angle

we know that $p.f = \cos \phi$
 put values
 $0.843 = \cos \phi$
 $\phi = \cos^{-1}(0.843)$
 $\phi = 35.164^\circ$

$\therefore \text{phase angle} = 35.164^\circ$
 $\phi = \tan^{-1}\left(\frac{R}{X_c}\right)$

Q5A) Given,

Line Voltage (V_L) = 400 V
 Frequency (F) = 50 Hz
 $Z_{ph} = 10 \angle 30^\circ$

where $Z = 10 \angle \phi = 30^\circ$
 Connection = Delta

Formula,

In delta connection
 $V_L = V_{ph} = 400 \text{ V}$
 $I_L = \sqrt{3} I_{ph}$

Find I_{ph} & I_L
 $I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{400}{10} = 40 \text{ A}$

$I_L = \frac{400}{\sqrt{3}} I_{ph}$
 $I_L = 69.2 \text{ A}$

$\therefore \text{Line Current } (I_L) = 69.2 \text{ A}$

To calculate power factor (p.f)

$p.f = \cos \phi$
 we know, $\phi = 30^\circ$

$p.f = \cos(30^\circ)$
 $p.f = 0.866$ (lagging)

p.f is lagging because angle is +ve. $\therefore$ Voltage leads current

$\therefore \text{Power Factor} = 0.866$

Total Active Power (P)

$P = \sqrt{3} \times V_L \times I_L \times \cos \phi$
 $= \sqrt{3} \times 400 \times 69.2 \times 0.866$
 $= 41469.62 \text{ W}$

$P = 41.47 \text{ kW}$

$\therefore \text{Total Active Power consumed} = 41.47 \text{ kW}$

Question No. 6

Q6B) Given,

$(8 + j6) \rightarrow \text{per phase}$
 Resistance $\rightarrow X_L = 6 \Omega$
 Connection = Star
 Frequency (F) = 50 Hz
 Line Voltage (V_L) = 230 V
 Resistance (R) = 8 Ω
 j is +ve so X_L is given
 X_L (Inductive Reactance) = 6 Ω

Formula:-

In star connection
 $I_{ph} = I_{ph}$ & I_L
 and $V_L = \sqrt{3} V_{ph}$

Finding V_{ph}
 $V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{230}{\sqrt{3}} = 132.79 \text{ V}$

finding impedance (Z)

$Z = \sqrt{R^2 + X_L^2}$
 $= \sqrt{8^2 + 6^2}$
 $Z = 10$

finding phase current (I_{ph})

$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{132.79}{10} = 13.28 \text{ A}$

we know in star connection $I_{ph} = I_L = 13.28 \text{ A}$

Converting $(8 + j6)$ into polar form

$10 \angle 36.87^\circ$
 $Z \angle \phi$
 we get $\phi = 36.87^\circ$

Power Factor (p.f)

$p.f = \cos \phi$
 $= \cos(36.87^\circ)$
 $p.f = 0.799$ (lagging)

p.f is lagging because inductive reactance is given

Apparent Power (S)

$S = 3 \times V_L \times I_L$
 $= 3 \times 230 \times 13.28$
 $S = 9163.2 \text{ VA}$
 $= 9.16 \text{ kVA}$

Reactive Power (Q)

$Q = \sqrt{3} \times V_L \times I_L \times \sin \phi$
 $= \sqrt{3} \times 230 \times 13.28 \times \sin(36.87^\circ)$
 $= 3170.47 \text{ VAR}$
 $Q = 3.17 \text{ kVAR}$

$\therefore \text{current} = 13.28 \text{ A}, p.f = 0.799$
 $VA = 9.16 \text{ kVA}, Q = 3.17 \text{ kVAR}$

Question No. 8

Q8B) Given:

Star Rating (S) = 5 KVA = 5000 VA
 Primary Voltage (V_1) = 220 V
 Secondary Voltage (V_2) = 110 V
 Secondary turns (N_2) = 50

Formula

$\frac{V_1}{V_2} = \frac{N_1}{N_2}$

To find primary turns

$\frac{220}{110} = \frac{N_1}{50}$

$\therefore N_1 = 50 \times 2 = 100 \text{ turns}$

$\therefore$ No. of turns in primary are 100

For primary full load current (I_1)

we know that $S = V_1 \times I_1$
 putting the values, we get

$5000 \text{ VA} = 220 \times I_1$
 $\therefore I_1 = \frac{5000 \text{ VA}}{220 \text{ V}} = 22.72 \text{ A}$



$$\therefore \text{Primary full load current } (I_1) = 22.72 \text{ A}$$

$$\text{For Secondary full load current } (I_2)$$

I_2

Formula:-

$$S = V_2 \times I_2$$

putting the values, we get

$$5000 \text{ VA} = 110 \text{ V} \times I_2$$

$$\therefore I_2 = \frac{5000 \text{ VA}}{110 \text{ V}}$$

$$I_2 = 45.45 \text{ A}$$

$$\therefore \text{Secondary full load current } (I_2) = 45.45 \text{ A}$$

$$I_1 = 22.72 \text{ A}$$

$$I_2 = 45.45 \text{ A}$$

$$N_1 = 100 \text{ turns}$$



Question No. 9

(Q9A) Given,

$$\text{Primary Voltage } (V_1) = 6600 \text{ V}$$

$$\text{Secondary Voltage } (V_2) = 440 \text{ V}$$

$$\text{Store Rating } (S) = 600 \text{ KVA} = 600000 \text{ VA}$$

$$\text{Primary No. of turns } (N_1) = 1200$$

ii) Secondary turns (N_2) :

$$\text{formula } \frac{V_1}{V_2} = \frac{N_1}{N_2}$$

putting values, we get

$$\frac{6600}{440} = \frac{1200}{N_2}$$

$$\therefore N_2 = \frac{1200 \times 440}{6600} = 80 \text{ turns}$$

$$\therefore \text{No. of Secondary turns } (N_2) = 80 \text{ turns}$$

i) Transformation Ratio (T) :

$$T = \frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$$

$$\therefore T = \frac{V_1}{V_2} = \frac{6600}{440} = 15$$



$$\therefore \text{Transformation Ratio} = 15$$

iii) Voltage/turn:-

$$\frac{V_1}{N_1} = \frac{6600}{1200} = 5.5$$

$$\therefore \text{Voltage/turn} = 5.5 \text{ V per turn}$$

iv) For Secondary Current (I_2)

$$\text{given that } p.f. = 0.8 \text{ (lagging)}$$

$$P = 400 \text{ kW} = 400000 \text{ W}$$

Formula:-

$$P = I_2 \times V_2 \times \cos \phi$$

$$\therefore p.f. = \cos \phi$$

$$\therefore \cos \phi = 0.8$$

putting values we get

$$400000 = 440 \times 0.8 \times I_2$$

$$\therefore I_2 = \frac{400000}{440 \times 0.8}$$

$$\therefore I_2 = 1136.36 \text{ A}$$



$$\therefore \text{Transformation ratio} = 15$$

$$\therefore \text{No. of Secondary turns} = 80 \text{ turns}$$

$$\therefore \text{Voltage/turn} = 5.5 \text{ V/turn}$$

$$\therefore \text{Secondary Current} = 1136.36 \text{ A}$$

Question No. 7

(Q7A) The various losses in the transformers are

- 1) Iron Loss
- 2) Copper Loss

1) Iron loss happens in the transformers many times to calculate it we have to calculate efficiency for total loss where the value of iron loss is kept same without any changes

2) Copper loss happens in transformers to calculate the efficiency we have to calculate losses first of full load Copper loss we have formula

$$P_{\text{Cu}} = (xI)^2 \text{ (given copper loss value)}$$

where x = load fraction

1 Given copper loss value in W

$$\therefore \text{Formula of finding efficiency } (\eta) =$$



$$\eta = \frac{\text{Total power}}{\text{Total power} + \text{Iron loss} + \text{Copper loss}}$$

$$\text{Total power} = x \times S \times p.f$$

$$\text{Iron loss} = \text{given value, eg:- } I$$

$$\text{Copper loss} = (xI)^2 \times \text{given value}$$

$$= x^2 \cdot C$$

$$\therefore \eta = \frac{x \cdot S \cdot p.f}{x \cdot S \cdot p.f + I + x^2 \cdot C}$$



Question No. 11

(Q11B) Fuse is a device which protects the household items from short circuit.

It works on the principle of Law of heating due to electric current

Fuse consist of low melting point metal wire inside the box which helps when excessive current flows due to short circuit, the wire melts easily when high current passes through it as it has low melting point

we can understand due to following cases:-

Sometimes in transformers due to high load leakage of current happens which needs to be fixed.

- a) When everything is normal :- If the current is passing through the wire constantly the small amount of heat created is dissipated in the air and the wire does not melt.
- b) When suddenly current increase :- As the current increases from the normal current to high current, it creates heat in the metal wire which melts fast as soon as the short circuit happens because it has low melting point.
- c) Generally we buy fuse of some more current capacity in the households because the fuse should not melt by

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few current fluctuations. For eg. if limit of current is 8A, we generally take fuse of 10A which prevents the household appliances from getting affected.

Fuse	(Miniature Circuit Breaker) MCB
1) Fuse works on the principle of low of heating due to electric current.	• MCB works on principle of magnetic flux or magnetic current.
2) Fuse is for one-time use only. Once the short circuit happens we have to replace the fuse again.	• MCB can be used multiple times as when the short circuit happens, it just cuts the current and switch goes off we can ON that switch again.
3) Fuse is much cheaper than MCB.	• MCB costs more than fuse & is expensive.
4) The reaction time of fuse is faster than MCB in short circuit (0.002 s).	• The reaction time is generally slow than fuse (0.2 to 0.3 s).
5) Fuse is used in small households,	• MCB are used in big buildings, etc.

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Question No. 10

(10A) Storage batteries are the batteries which stores current inside them and delivers output when required.

Acid Batteries	Si-Lead Batteries	Silicon-Carbon
1) These are generally heavy batteries.	2) These are compact batteries.	3) These are little more compact batteries.
2) They can store current for less time compared to other batteries.	They can store current for more time than acid batteries.	They can store current for much more time than Acid & Si-Lead batteries.
3) They have low charge cycles 500-600 cycles.	They have high charge cycles 1500-2000.	They have high charge cycles 2000-2500.
4) Less durable.	More durable.	More durable than Acid & Lead batteries.
5) Used in heavy cars, trucks, etc.	Used in Mobile Phones, Laptops, etc.	Used in smartphones, Phones, Laptops.

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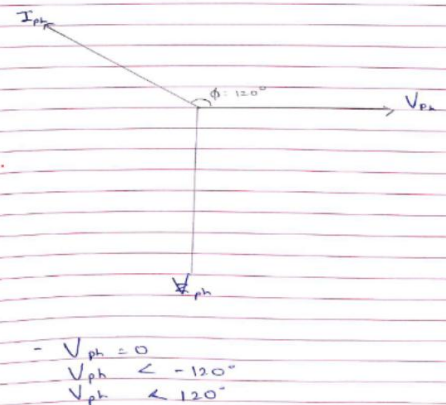
6) It contains acids and positive & -ve plates.	It contains lead & silicon which were used in old phones.	It contains silicon & carbon layers which stores current for more time and are very slim and stores current for very long time.
7 It supports Slow charging.	It supports Fast charging.	It also support Fast charging.

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Question No. 4

(4A) Given,
 $p.f = 0.8$

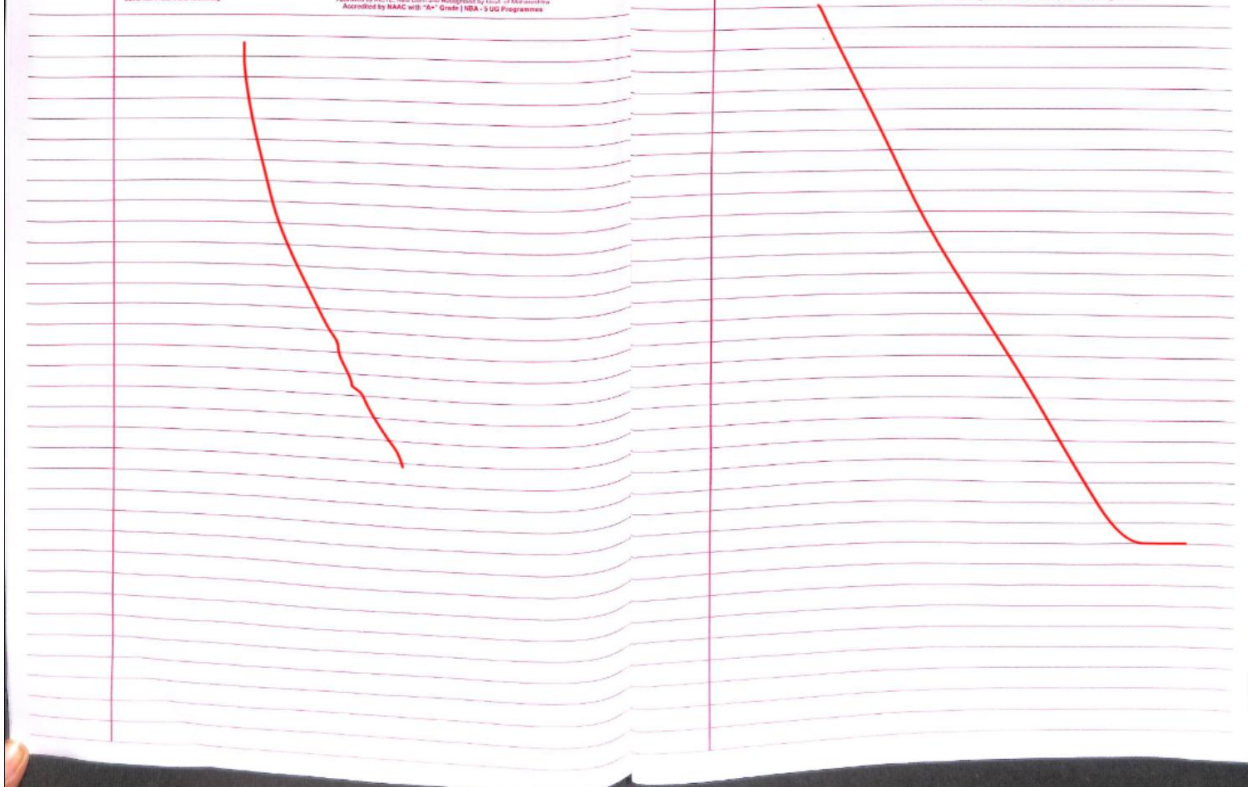


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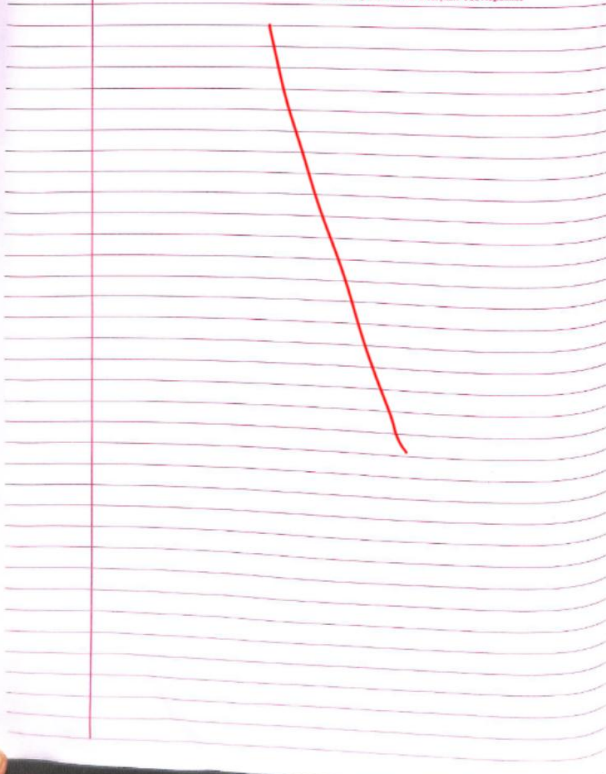
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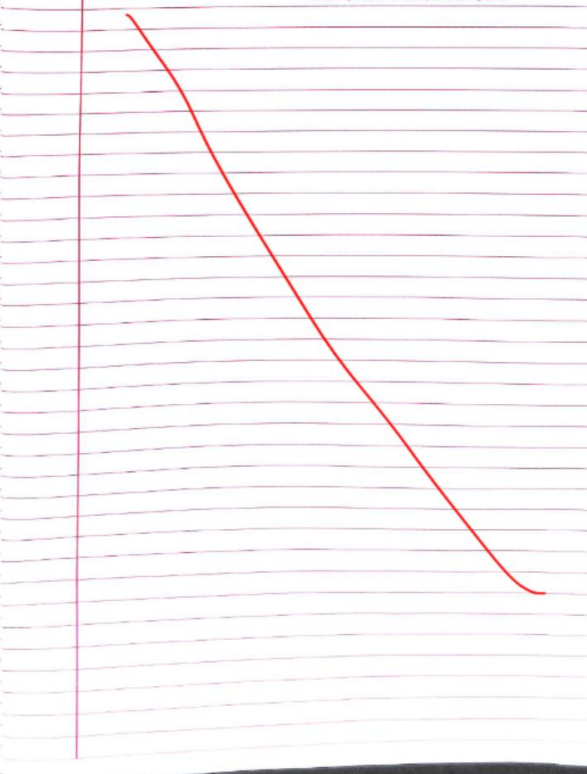
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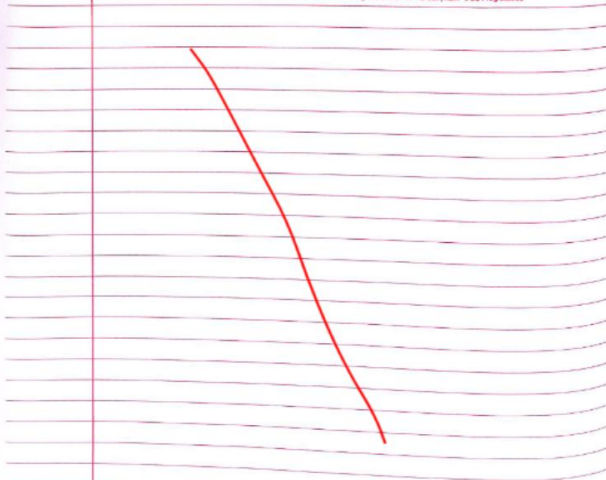
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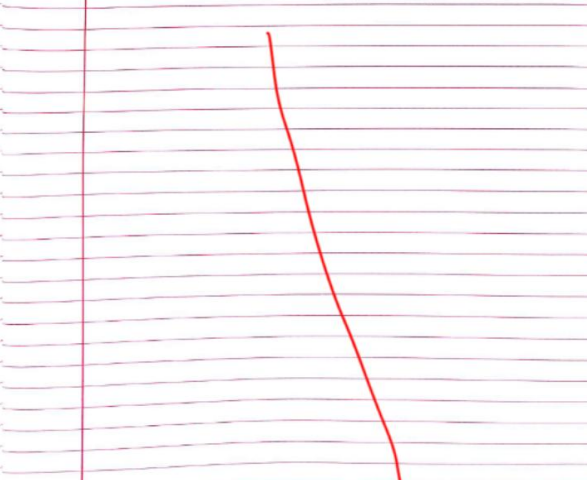
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$$p.f = \frac{P}{Z} = \cos \phi$$

$$\phi = \tan^{-1} \left(\frac{X_L - X_C}{R} \right)$$

$$\text{Impedance}$$

active = W
reactive = VAR
apparent = VA

$R = 50 \Omega$
 $L = 0.1 H$

P.F.
0.8

$C = 0.50 \times 10^{-6} F$
 $V_{rms} = 230 V$

$$\eta = \frac{\pi \cdot S \cdot p.f}{\pi \cdot S \cdot p.f + i_{iron} + G_{core} \cdot \omega \cdot p.f} = 50 H_z$$

$$I_L = \sqrt{3} I_{ph}$$

$$I_{ph} =$$

$$I_L = 6.68$$

$$\sqrt{3} V_{ph} = V_L$$

$$129.78$$

primary full load current =

$$P = V_2 \times I_2 \times p.f$$

$$400 = 440 \times 0.8 \times I_2$$

$$\therefore I_2 = 1.136 A$$